These 'Recommendations' are included at the front of the CBSG PVA Report on Javan rhinos even tho' they were not all discussed or agreed at the June meeting. They were also included in the package given by Prince Philip to President Suharto.

Captive Breeding Specialist Group

Species Survival Commission
International Union for the Conservation of Nature and Natural Resources
U. S. Seal, CBSG Chairman

JAVAN RHINOCEROS

Rhinoceros sondaicus

POPULATION VIABILITY ANALYSIS

RECOMMENDATIONS

1. Continue and intensify protection of the rhinoceros population at Ujung Kulon. The major threats are poaching and disease. Removal of 1 animal every 2 years is sufficient to prevent population growth and is a threat to survival of this small population. Disease threats to the wild population should be evaluated.

2. Establish a captive breeding program in 1990 with the objectives of collecting as full a genetic representation of the wild population as possible and expanding the total captive population to 150 animals as soon as possible.

   a. Establish 2 protected captive populations as soon as possible to protect against loss of the species and to assist expansion of numbers. One of these populations should be located near a site on Sumatra selected for eventual reintroduction into the wild. One population might be located on Java either in a zoo or a facility that can be expanded to hold 15-25 animals. It is essential that all captured animals be placed in groups in facilities designed for secure management and breeding. A captive population ? also should be located outside of Indonesia to provide maximum security for the species.

   ? b. Remove 18-26 animals from the population at Ujung Kulon to establish the captive populations. This should be done with continuing evaluation, according to the suggested guidelines, of the experiences with capture and postcapture management and mortality. The wild population appears to be at carrying capacity which is limiting further growth. It can recover from this removal within 10 years if growth rates increase to 3.5+% as occurred during 1971-1981.

3. Expand the total captive population to a minimum of 80 - 100 animals with an annual growth rate of 3.5% before beginning a release program. This is necessary to protect the species gene pool and to have sufficient animals to supply a release program without jeopardizing the demographic security of the captive population and the species gene pool.

4. Plan to restore the Javan Rhinoceros to reserves throughout its historical range to a total population of at least 2000 animals and manage the individual populations as a single metapopulation.

5. Initiate a field research program, using radiotelemetry, with the Ujung Kulon rhino population to provide information on the population dynamics and ecology of the species in preparation for future reintroduction programs. This will also provide additional protection for the population.

6. Initiate molecular genetic studies on all of the animals, as captured, to evaluate remaining levels of heterozygosity and to assist in identifying pedigree relationships among the animals as a guide to the captive breeding program. These studies will also allow comparison with samples to be collected from the Vietnamese population to evaluate the relationships of the two populations.

7. Initiate serological and laboratory studies on the rhinos as a guide to their health status and disease history. Samples should also be collected from banteng as a baseline for any future disease outbreaks in the rhinos and banteng.

8. Initiate reproductive studies of the species, including cryopreservation of semen, to assist in captive breeding management, preservation of genetic material, and to determine if the wild population is having reproductive problems.

9. Establish a collaborative species recovery and management program to develop a genetic and demographic masterplan for the captive and wild populations and to develop the necessary resources to undertake these programs.

Memo

to: Simon Stuart
from: Kathy MacKinnon
date: 10 December 1989
subject: Captive breeding programme of Javan rhinos
cc: Russell Betts, WWF Indonesia Programme
Charles Santiapillai

I recently had the pleasure of flying back from Yogya with Dr Rubini, the former D-G of PHPA and he brought up the topic of captive breeding schemes for Javan rhinos. Since then Charles has kindly lent me a copy of the CBSG Population Viability Analysis on Javan rhinos. Some of the recommendations are surprising and can only add to the concern already felt by many conservationists concerning the whole topic of captive breeding of Indonesian rhinos.

The programme for captive breeding of Sumatran rhinos can hardly be hailed as a success. Mortality has been high - I hear figures between 25% here and 60%!!! overall. There is some evidence that poaching of Sumatran rhinos has also increased within reserve areas. To date there have been no births in captivity as a result of the programme. Perhaps this may have something to do with the fact that animals are rarely lodged in pairs but every zoo involved needs to have one animal for display? Maybe there is something about rhino breeding biology that I have failed to understand, but this looks very much like animals caught for display rather than a real and committed effort to captive breed. Most worrying of all, I see no investment from this programme going into the reserves known to harbour viable wild populations. Howlett's generously donated two clapped out old vehicles - hardly a major contribution to conservation in the field. We all know that money changed hands but perhaps the zoos should be more concerned about where that money is going.

Now it seems the Javan rhino is also to be 'saved'. I am particularly concerned about two recommendations in the CBSG report.

a captive population should be based outside of Indonesia
Why and where? Are we talking about in American zoos or in some well-managed reserve (where?) within Southeast Asia within the Javan rhinos' former range?. Personally, I would leave the Javan rhinos alone in Ujung Kulon but if any animals are to be removed for breeding then surely the best option is not to put them in any zoos but to have a population in a very large, well-protected enclosure in a well-protected (where?) reserve in Sumatra and allow them to breed in wild conditions. IUCN, WWF, the CBSG and the American zoos could all earn themselves a lot of merit by helping to improve protection and management of that reserve.

remove 18-26 animals from Ujung Kulon
Are the CBSG serious? The whole population is only about 70 animals. 18-26 rhinos may be the whole breeding population, never

mind the disruption and distress caused by removing a third of the population. Rhino traps are made by felling trees; trees aren't so common in that swampy palm habitat that the rhinos like. Are the trappers going to carry in wood (difficult and expensive) or be given the go-ahead to totally destroy the habitat?. These matters require some serious consideration.

What is wrong with leaving the rhinos in Ujong Kulon and allowing the population to build up itself?. They seem to have recovered very nicely from a low of 28 animals to their present levels with only a marginal improvement in protection. Everyone agrees Ujung Kulon is a priority area and there will be a New Zealand government project there. Where is the evidence that U.K. is at full carrying capacity for rhinos?; surely if the rhinos feel crowded there is plenty of room for them to move into Gn. Honje where they once roamed.

I know all the arguments about small populations and dangers from disease, overcrowding and even the likelihood of Krakatau erupting again. Has anyone considered that Krakatau's last effort may have helped the rhino to survive till today by wiping out a few coastal villages and discouraging settlement? Until we see compelling evidence that translocation of rhinos is no problem and that a captive breeding programme has a very high likelihood of success, mightn't it be better to leave well alone.

It is wonderful news that Vietnam has a population of Javan rhinos but that surely doesn't mean we can now take unacceptable risks with the Indonesian population. Those of us working in Indonesia would prefer to see less attention paid to expensive 'glamorous' captive breeding schemes and reintroduction programmes and much more effort concentrated on the mundane but absolutely necessary task of effectively protecting and managing some of the priority reserves. This is Indonesia's only hope of preserving her fantastic wildlife, including Javan rhinos. If the American zoos wish to help that is wonderful but let them provide funds for real protection of habitats; only if that fails should we look to these more exotic solutions.

I hope you can distribute these comments to interested parties. I will be in U.K. 12 Dec to 10 Jan if you want to contact me.

WWF Regional Programme
(Indo-China), PO Box 1[illegible].
Bogor, Indonesia
Tel: (0251) 327316
Fax: (0251) 328177 BADAKBOGOR
18 March 1990

Mr Anton Fernhout
WWF-International
CH-1196 Gland
Switzerland

Re: Conservation of Javan rhino in Indonesia

Dear Anton,

I am writing to you about the proposed plan here in Indonesia to capture some Javan rhinos from Ujung Kulon NP to be bred in captivity at Taman Safari (Safari Park) in Cisarua near Bogor. According to a recent Kompas Newspaper report, such a programme has the support of IUCN.

This is very disturbing to say the least. The number of animals, according to the PVA analysis produced by the IUCN/SSC Captive Breeding Specialist Group (CBSG) may range from 15-25. I have already expressed my concern to Simon Stuart at the SSC and so he is aware of my misgivings about the whole scheme - if it were to go ahead.

At the June meeting convened by IUCN/SSC and PHPA, there was much argument over the relative merits of in situ and ex situ conservation of the rhinos in Indonesia in general and the Javan rhino in particular, with Prof. Schenkel passionately arguing in favour of the former. But given the reality of the Javan rhino situation (just one viable population confined to a single locality in Indonesia), even Prof. Schenkel accepted the wisdom of establishing a second population in Indonesia within the Javan rhino's former range. In our discussions, the only area that met the preliminary conditions to be a target site for re-introduction of some founder animals (to my view about 3 pairs at the most) was the Way Kambas Game Reserve in Southern Lampung, where the animal once existed until the 1930's. It was therefore recommended "that two additional populations be set up as soon as feasible" (recommendation 8) and "one of the initial captive propagation sites could be situated in or adjacent to a prime translocation or re-introduction site in Sumatra. The other captive propagation site should be located near Bogor based upon a detailed site analysis" (recommendation 9).

It was also agreed that "Before removals from Ujung Kulon can take place, it is essential that the receiving sites be adequately prepared, including all the necessary aspects of protection" (recommendation 10). Furthermore, it was also agreed that "A Rhinoceros Conservation Unit (RCU) should be established within the PHPA to have the responsibility for all operational aspects of rhino management in Indonesia" (recommendation 23).

Nowhere in the document arrived at the end of the meeting does it specify the number of Javan rhinos to be captured. Before this could be done, we understood that there would be a thorough investigation of the situation in Ujung Kulon and an assessment of the relative merits of the target areas (in Indonesia) by the RCU. To this date, there has been no RCU set up with the PHPA as planned in June, although a proposal from WWF-Netherlands recommending (and funding) Dr Nico van Strien to head such a Unit has been given to PHPA for their consideration.

When Simon sent the draft of the June meeting to Drs Effendy Sumardja on 31 July, 1989 he mentioned that the Annex 2 (Population Viability Analysis or PVA) was being prepared by Ullie Seal and so was not enclosed. I was asked by Drs Effendy Sumardja and Mr Widodo on behalf of the PHPA to review the draft, which I did and sent also a copy of my observations to Simon. I do not know if PHPA did endorse my comments and send its reply to Simon. Then I left for Lausanne for CITES meeting where Simon and I once again discussed the draft informally. I have raised specifically two issues:- one is over the number of Javan rhino to be captured in Ujung Kulon for re-introduction into a secure reserve in Sumatra. This was not clear in the draft. It only mentioned, ".....removal of animals from Ujung Kulon to establish other populations" (recommendation 8). I wanted to know specifically how many were to be captured. The other issue concerned the need beforehand to rehabilitate and strengthen possible release site such as Way Kambas <u>before</u> any capture operations could be commenced.

Having raised these issues on behalf of the PHPA, I was surprised to receive from CBSG a copy entitled, :JAVAN RHINOCEROS <u>Rhinoceros sondaicus</u> : POPULATION VIABILITY ANALYSIS on 27 November 1989 in which the compilers have recommended the removal of "18-26 animals from the population at Ujung Kulon to establish the captive populations" (recommendation 1b). I feel that such a removal would be unwise and this is my main worry. I have expressed my concern to Simon over this in a letter dated 10 December 1989 (copied to you, Chris Hails and Chron. File). According to a previous PVA recommendations sheet on Javan rhino (Faxed from USA on 27 September 1989), it is mentioned that "Protect the rhinoceros at Ujung Kulon against any poaching <u>since the removal of even 1 animal every two years is sufficient to prevent population growth and is a threat to survival of this small population</u>" (recommendation 1). If the risk is so high then how could anyone justify the capture of 18-26 animals from Ujung Kulon to establish a captive breeding programme? This is my genuine fear. I hope I am not misunderstood by anyone of under-rating the importance of captive breeding in conservation. As far as the Javan rhino is concerned, such as small population as the one we have in Ujung Kulon (estimated to be about 60) cannot withstand the removal of 18-26 animals - breeding stock at that.

Simon in his unsigned letter of 1 February 1990, felt that I might be going back on the agreement. To allay his fears I outlined my views in a letter dated 6 March 1990 (copied to you, Kathy MacKinnon, Chris Hails, Pascale Moehrle and Chron. File) in which I emphasised that I am not against captive breeding per se. My concern was solely with the proposed removal of such disproportionate number of Javan rhinos from Ujung Kulon for captive breeding programme.

I now feel very much disappointed at the way the Javan rhino conservation is set to proceed. The proposed plan, if carried out will not do any good to the only viable Javan rhino population in the world. It would make it even more vulnerable to disease, inbreeding depression, environmental perturbations or habitat changes etc. In a population of 60 animals, only about 20-30 may be capable of breeding. In the capture of 18-26 Javan rhinos how many animals would succumb? Cisarua and Surabaya are over 100 km apart in Java but they have a female and a male Sumatran rhino respectively - apparently as a start in the right direction towards breeding in captivity!

While Kathy MacKinnon and I were expressing our genuine fears that some people in Indonesia may find loopholes in the draft to remove the animals, the newspapers in Indonesia have already begun to confirm our fears. We both have nothing to gain from raising our concern except that we strongly feel that the Javan rhino might have a better chance of survival within its natural habitat within its former range in Indonesia than in an artificial breeding facility in an urban centre be it in Cisarua or Cincinnati.

I wish the CBSG every success in their efforts. But I would not like to be a party to the removal of so many Javan rhinos from Ujung Kulon NP to be bred in captivity in Zoos, or Safari Parks. I would be happy to assist in the re-location of a few founders (say 6 animals) to a target area (such as Way Kambas) provided the release site is well rehabilitated and made secure beforehand. I may be an old fashioned conservationist but I still would like to believe that WWF stands for the protection of wildlife species in their natural habitat. Computers and PVA analyses alone cannot ensure the long term survival of the rhinos if in the meantime, their habitat is gone.

With kind regards.

Yours sincerely,

Charles

Charles Santiapillai

cc: Simon Stuart, Chris Hails, Pascale Moehrle, Kathy MacKinnon, Chron. File.

T

Fax No. (022) 642 826

15 March 1990

Simon Stuart, IUCN/SSC
Avenue du Mont Blanc
Ch 1186 Gland
Switzerland

Sender: Jan Wind
Jl Guntur 23
Bogor
Fax:021 710551

Things are moving fast regarding the Javan rhino.

Is it really IUCN's intention to encourage Taman Safari Indonesia to establish a captive breeding programme, taking 15-25 animals from Ujung Kulon as your document seems to imply? If not please respond immediately to the relevant authorities in Indonesia and the Indonesian media (e.g. Kompas newspaper and Jakarta Post).

We are very concerned.

Ir Jan Wind, World Bank National Parks Project
Chairman, Kabar Alam Belanda-Indonesia

Dr Kathy MacKinnon, EMDI Project

Kathleen Mackinnon

Dr Charles Santiapillai, WWF Indonesia Programme

C Santiapillai

Ian Craven, WWF Indonesia Programme

Dr H.D. Rijksen RIN Holland.

IKRAM S. SANGADJI
Balai Latihan Kehutanan
Bogor - SECM.

IAN CRAVEN

Kuswata Kartawinata
KUSWATA ICARTAWINATA
UNESCO/RUSTSEA

Russell A. Mittermeier
WWF Representative/Indonesia
Informal IUCN Rep./Indonesia

Fred Smiet
lecturer SECM, Bogor

M.J. SILVIUS
National Coordinator
ASIAN WETLAND BUREAU
INDONESIA

Herbert Plumont
lecturer SECM, Bogor

D.A. Holmes
(Editor, Bulletin of Ornithological Society of Indonesia)

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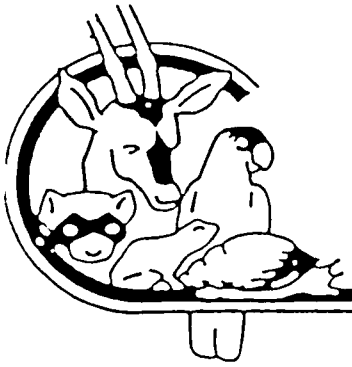

Captive Breeding Specialist Group

Species Survival Commission
International Union for the Conservation of Nature and Natural Resources

U. S. Seal, CBSG Chairman

JAVAN RHINOCEROS

Rhinoceros sondaicus

RECOMMENDATIONS

2. Establish a captive breeding program in 1990 with the objectives of collecting as full a genetic representation of the wild population as possible and expanding the total captive population to 150 animals as soon as possible.

   a. Establish 2 protected captive populations as soon as possible to protect against loss of the species and to assist expansion of numbers. One of these populations should be located near a site on Sumatra selected for eventual reintroduction into the wild. One population might be located on Java either in a zoo or a facility that can be expanded to hold 15-25 animals. It is essential that all captured animals be placed in groups in facilities designed for secure management and breeding. A captive population also should be located outside of Indonesia to provide maximum security for the species.

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3. Expand the total captive population to a minimum of 80 - 100 animals with an annual growth rate of 3.5% before beginning a release program.

IUCN Recommendations (Nov. 1989)

leading to ⟹

JP- March 9, 1990

Foundation set up to protect rhinoceroses.

JAKARTA (JP): A foundation has been set up to protect the decreasing number of rhinoceroses in Indonesia.

Forestry Minister Hasjrul Harahap inaugurated the body, called the *Foundation of Friends of The Rhino*, here Tuesday.

The minister said the foundation reflected Indonesia's determination to preserve the country's forests and wildlife.

The foundation will raise rhinoceroses on the island of Panaitan off Ujung Kulon in West Java, involving both domestic and foreign breeding experts.

"We want to show the world our seriousness in maintaining a balance between the utilization and the preservation of natural resources for the benefits of the young generation," Harahap told participants during the inauguration ceremony, according to the daily *Merdeka*.

Protection of the animals on Panaitan would be also beneficial for people who carried out research on rhinoceroses in the future, the minister said.

About 760 rhinoceroses are currently found in forests in Ujung Kulon and in several places in Sumatra, according to another official of the Forestry Ministry.

Jakarta Post

9 March, 1990

Sukisna, D-G of PHPA is Head of Foundation

Taman Safari Indonesia Jadi Obyek Wisata Nasional

Bogor, Kompas

Taman Safari Indonesia (TSI), obyek wisata khas yakni taman hewan terbuka satu-satunya di Indonesia yang terletak di Desa Cibeureum Kecamatan Cisarua Kabupaten Bogor, akan diresmikan oleh Menteri Parpostel Soesilo Soedarman menjadi obyek wisata nasional. Selain itu, Menteri Kehutanan Hasyrul Harahap akan menyatakan TSI sebagai wilayah kegiatan konservasi *Ex situ*.

Demikian diungkapkan Direktur TSI, Frans Manangsang, kepada wartawan Minggu siang (11/3). Disebutkan TSI yang didirikan pertengahan tahun 1986 dengan 270 satwa dari mancanegara, kini dihuni 1.000 lebih satwa yang terdiri atas 150 jenis satwa mancanegara dan Indonesia. Saat ini TSI telah mampu menyerap sebanyak 1,2 juta wisatawan per tahun, di antaranya 15 persen wisatawan mancanegara.

Lokasi TSI, semula akan digunakan sebagai *home base* sirkus. Namun dengan berbekal pengetahuan tentang binatang buas dan kecintaan pada alam lingkungan, akhirnya tercetus gagasan mendirikan Taman Margasatwa untuk menangkarkan satwa-satwa langka.

Selain itu, menurut Frans, IUCN *(International Union for Conservation of Nature and Natural Resources)* menjadikan TSI sebagai alternatif pertama untuk penangkaran badak Ujungkulon dan tempat proyek pelestarian banteng Jawa.

Fasilitas baru

Untuk menghindari kejenuhan pengunjung yang sekaligus juga menunjang kehidupan TSI, menurut Frans, pihaknya senantiasa menampilkan atraksi dan fasilitas baru. Tahun ini, TSI dilengkapi dengan *caravan camping ground* atau *mobile home* yang menyerupai vila mewah. "Caravan ini merupakan yang pertama di Indonesia dan juga Asia," kata Frans seraya menambahkan, pada hari Lebaran nanti, mulai dioperasikan pula kereta gantung yang melintasi taman rekreasi. (pun)

Kompas,

14 March 1990

According to Frans (Manangsang, Director of Taman Safari Indonesia) Taman Safari is IUCN's first alternative for captive breeding of the Javan rhino and conservation of Javan banteng.

Indonesian Response.

New Scientist 15 August 1990

Received 31/8/90. Time given us a good opportunity to respond & state our preference for 'in situ' conservation.

All the world's a zoo

Captive breeding may no longer be enough to save endangered species. Is it time to start manipulating the animals left in the wild?

Claire Neesham

Alan Compton; Bruce Coleman

Playing hard to get: the Sumatran rhino is hard to find and more difficult to catch, but an arranged marriage may be its only hope

A LITTLE over a year ago, a group of conservation biologists flew into Bogor, in Indonesia. They had gone to work out a plan to save the rarest of the world's rhinoceroses—the Javan and Sumatran rhinos. The biologists were armed, not with guns and razor wire, but with a personal computer and programs designed to work out what the chances of survival were for small populations.

The team fed information about the age, sex and distribution of rhinos into the computer, which then produced estimates of the rhino's chances under various conditions. From these estimates, the biologists designed a survival plan: the rhinos, they decided, should be reorganised into new populations, some in captivity and some in the wild, and the animals should be managed as a whole—as a "megazoo".

Managing animals in the wild as closely as captive populations is a controversial strategy. But as Peter Bennett, a conservation coordinator for the British Zoo Federation, points out: "The term 'megazoo' may have connotations of Victorian animal houses, but you can't avoid the fact that in 100 years' time it is likely that no animal will be able to survive in the wild without close management, because there will be no wild left."

The World Conservation Union (the IUCN) has a group of captive breeding specialists advising conservationists on issues related to captive breeding as part of the Species Survival Commission. The group coordinates international breeding programmes and provides zoos, wildlife parks and other organisations with technical assistance for managing small populations, both captive and wild. "We are moving towards the situation where there is no distinction between captive and wild," says Tom Foose, a member of the group. "Unless we exercise close management in the wild, the smaller populations are not going to survive."

The Javan rhino (*Rhinoceros sondaicus*) and the Sumatran rhino (*Dicerorhinus sumatrensis*) are typical of small populations threatened with extinction. There are fewer than 1000 Sumatran rhinos, and these live in small, isolated populations. The Javan rhino is rarer still, with a single known population of around 70 animals, based in the Ujong Kulon National Park in Java. With poaching and the continued destruction of their habitat, these populations are likely to dwindle still further.

Although guards and fences can help to slow the losses, a small population's survival does not depend entirely on the number of animals. Chance variations in other factors can also affect it. Disease or a natural disaster such as a hurricane can wipe out a small population. Unexpected failures in breeding, or a bias in sex ratios, can also alter the structure of the population. And inbreeding, or no breeding at all, accelerates the loss of genetic diversity: a gene pool can very quickly shrink to a gene puddle.

These problems are characteristic of any small isolated population, including animals living in zoos. "Zoos have been

Jeff Foott/Bruce Coleman

Centre of controversy: plans to "manage" the endangered Florida panther have upset conservation groups

confronted with the problems of managing small populations for many years, and have developed analytical techniques for minimising the risks to the survival of these small populations," says Bennett. This has led the IUCN's captive breeding group to the conclusion that it is now time to start managing shrinking wild populations as if they were in captivity. "In most cases this is not intervention, it is just good management," says Georgina Mace, of London Zoo.

Curators at zoos and wildlife parks have taken management of their animals more seriously over the past 20 years and are keen to play a leading part in conservation through captive breeding (see "Breeding by numbers", *New Scientist*, 1 September 1988). To this end, zoos around the world are developing captive breeding programmes. By splitting captive populations among several zoos around the world, the zoos maintain the genetic diversity of the species so that when surplus animals are returned to the wild, they have the wherewithal to cope with their natural environment, and add new genes to the local gene pool. This strategy also helps to prevent a single disaster from wiping out a whole species.

Stud books and computer databases play a central role in animal management. One of the most widely used databases is the Animal Record Keeping System (Arks), developed at Minnesota Zoo in the US, and now used by more than 300 zoos around the world. The central database holds information on the pedigrees of more than 100 000 animals in 32 countries, allowing curators to identify suitable mates for animals in their collections.

In theory, a database such as Arks should make it easy to prevent inbreeding. In practice, it is more difficult. For many species, all the zoo animals are descended from just a few animals introduced from the wild. And there is sometimes no record of the relationship between present populations and their founding fathers and mothers.

The problem of incomplete records has prompted several groups to develop programs that analyse the genetic make-up of populations and their demographic structures. These include "Sparks", the Single Population Analysis and Record Keeping System, devised by the group at Minnesota Zoo, and Gene Drop programs, which estimate the loss of genes down through the generations and calculate the ideal distribution of those genes. Zoos and parks can then set up breeding programmes to achieve that ideal distribution.

New techniques in biochemistry and genetics are beginning to fill in some of the missing information. Genetic fingerprinting, for instance, can identify an animal's parentage and the degree of genetic diversity in a particular population. Improvements in DNA analysis should lead to more accurate information.

Zoos are using these techniques to gather information

Edgar T. Jones/ARDEA

Despite attempts at captive breeding, the black-footed ferret may never recover in its natural habitat

on the genetics of small captive populations. London Zoo has just fingerprinted the scimitar-horned oryx at London and Amsterdam Zoos. The tests showed that the animals in Amsterdam had a greater variety of genes than those in London. This allows the zoos to improve their breeding programme for oryx to increase the diversity of the London population.

Biologists working in the field can apply the same techniques to wild animals to work out their pedigrees. Refinements to DNA analysis mean that it is now possible to obtain a genetic fingerprint from the tiny amount of DNA in a single hair, or from the cells in urine.

In the early 1980s, conservationists and zoo biologists started to build computer models that predicted the survival of populations, based on genetic and demographic analyses. One of the first studies took place in 1983 in Yellowstone National Park in the US. Mark Schaffer, a biologist with the US Fish and Wildlife Service, calculated that the park had to have at least 50 female grizzly bears for the population to have a 95 per cent chance of survival. He called this the "minimum viable population". This method of calculation has limitations. Schaffer's model considered only the reproductive capacity of the population based on the ages of the animals. In reality, many other factors affect the viability of a group of animals.

This led Mike Gilpin and Michael Soule, of the University of California, San Diego, to suggest adding all the other interacting factors, such as variations in the environment, catastrophes and genetics, into the computer models to produce more accurate simulations. They called their technique "Population Viability Analysis".

Gilpin and Soule first tried their technique in 1986 on the endangered Concho water snake in Central Texas. Since then, other researchers have applied variations of the technique to other species, including the black, Sumatran and Javan rhinos, the red wolf, the Californian condor, the Florida panther and the Puerto Rican parrot (see Box).

Over the past 18 months, the IUCN's captive breeding group has held a number of workshops based on population viability analysis. Field biologists provide the data for the analyses from their observations of real populations of animals. The conservationists then use the results of the analyses to design "Species Survival Plans".

Collecting the essential information to produce an accurate analysis is often tricky. In the case of the Javan rhino, gathering the data to set up the computer model was particularly difficult. There are none of these rhinos in captivity and they

Out of the zoo and into the rainforest

IT DIDN'T take a computer to work out that the Puerto Rican parrot needed better management. At a workshop run by the IUCN captive breeding group in June last year, one of the participants watched a parrot eating paint from the wall of the Luquillo aviary. This prompted him to recommend more careful management at the aviary.

This simple line of reasoning contrasts with the scientific analysis on which the participants at the workshop based the rest of their recommendations. At the week-long workshop, members of the captive breeding group, along with field workers and the US Fish and Wildlife Service, applied population viability analysis programs devised by the captive breeding group to quantify the parrot's chances of survival. They then used the results to map out a Species Survival Plan.

The Puerto Rican parrot, *Amazona vittata*, is heading for extinction. In June last year it existed in the wild as a single population of 34 birds in the Luquillo Forest, part of the Caribbean National Forest on Puerto Rico. There was also a captive population in Luquillo and plans to establish another at Rio Abajo with a total of 46 birds.

At one time there may have been as many as a million Puerto Rican parrots across the island. A hurricane in 1899 may have started off the bird's decline. But, since then, disease, loss of habitat and poaching have led to a continuing fall in numbers. Over the past 20 years, the Fish and Wildlife Service has made extensive efforts to protect the wild birds, guarding the nests of each wild parrot to deter egg thieves, and transferring eggs and birds between the wild populations and the aviaries.

Despite these measures, the viability analysis did not give very encouraging results. It gave the birds a 66 per cent chance of survival over the next century, unless more drastic steps are taken to help them. The biologists at the workshop suggested a number of measures that would give the birds a better chance. These included setting up a "master plan" for the wild and captive birds, involving the Fish and Wildlife Service. The plan involves establishing at least five more populations in the wild and more groups in captivity, and forming at least one population on the mainland, probably at Houston Zoo in Texas. All these groups would be managed as a single population to ensure genetic variety.

Field biologists were advised by those at the workshop to use techniques such as genetic fingerprinting to identify the parentage of individual birds—a first step to setting up a studbook for the species. For this the workshop recommended the Arks database and the Sparks record-keeping program, both developed at Minnesota Zoo, and Medarks, a medical database. These would give field biologists access to some of the expertise on small populations built up in zoos. There was also a need for practical action, including provision of better food supplies, routine veterinary care and gathering more information on the parrot's behaviour.

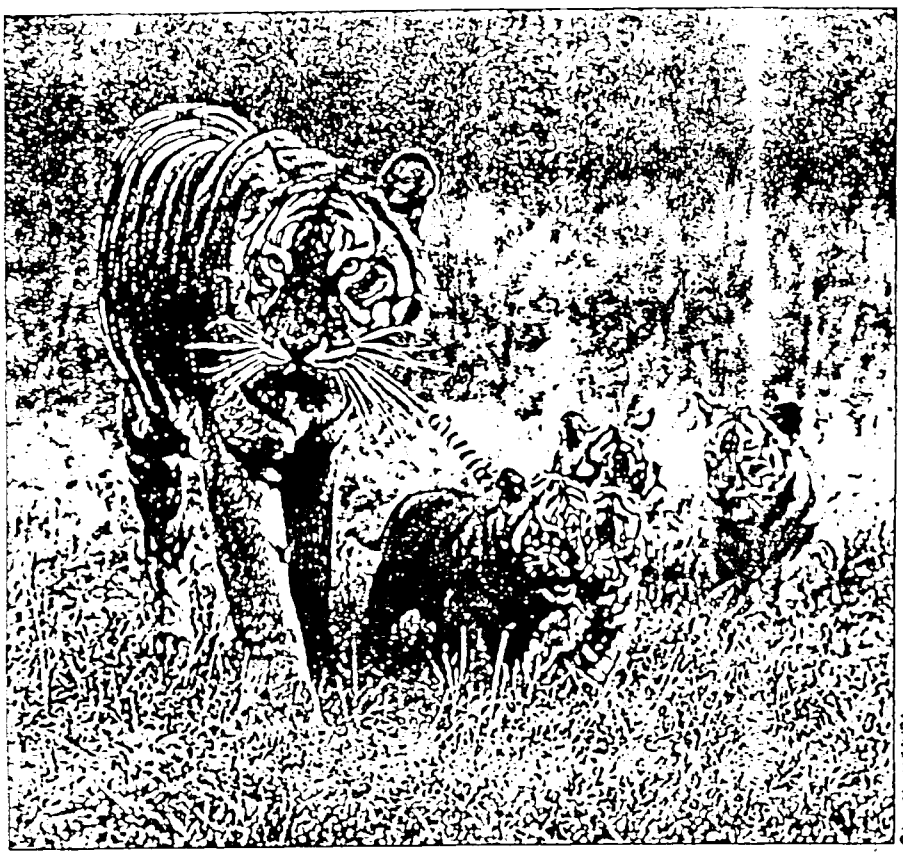
The computer analysis which formed the basis of these recommendations involved a simulation of the parrot population based on a computer model developed in 1980 by James Grier, of North Dakota State University. The model calculates the probability of extinction over a specified period, either starting from the actual number of birds and the ratio of males to females or from a hypothetical population.

In addition to this basic model, Bob Lacy, of the Brookfield Zoo, Chicago, and a member of the IUCN's captive breeding group, has added programs that simulate the mean population growth, carrying capacities, effects of various environmental conditions on reproduction, and the impact of catastrophes.

The basic information for the modelling came from field biologists who had studied the Puerto Rican parrot. Their data were run through the model thousands of times with different parameters, to calculate the probability of the population surviving over the next 100 years. It showed that neither the carrying capacity of the habitat nor environmental variation in the Luquillo forest have much impact on the wild birds' survival. The main factors controlling the rate of extinction were disease and natural catastrophes such as hurricanes. Lacy estimated that the wild population of parrots would be halved if a hurricane hit Puerto Rico.

In June 1989, the chance of a hurricane hitting the island in the next year was reckoned at one in 30. A month later, Hurricane Hugo blasted through Puerto Rico. Just as the model predicted, half the parrots were lost. Lacy believes that most of the birds died after their feathers were blown off or because they were blown out to sea. The hurricane also destroyed much of the forest, leaving the parrots vulnerable to hawks.

According to Lacy, there are around 30 wild birds left. He says things could have been much worse but for the fact that some of the workshop's recommendations had already been implemented. Captive birds already had good indoor cages, and a food store had been organised. "We now face a dilemma," says Lacy. "Do we take all the birds into captivity or do we carry on following the recommendations from the population viability analysis?" Discussions are continuing, but the least those who attended the workshop now have confidence in the accuracy of the computer's predictions. □



Gerald Lacz/NHPA

Candidates for the megazoo: despite this healthy litter of kittens the population of Sumatran tigers is shrinking rapidly. Plans to manage the species need to be made now. A "survival plan" for the Bali starling may be too late to save it from extinction

Hans Reinhard/Bruce Coleman

are especially difficult to observe in the wild. Information on the age and number of animals of each sex, for example, came from measurements of footprints. (Adults leave bigger prints, and if small prints accompanied the larger ones, then that adult was likely to be female.) After a workshop on the Javan rhino, attended by the captive breeding group, members of the Indonesian Conservation Department and field workers, the group made a series of recommendations based on the results of the population viability analysis. In particular, the group recommended that both wild and captive animals should be managed as a single population. It also emphasised the need to transfer techniques developed in captivity to animals in the wild. "While it is necessary, it is no longer sufficient merely to protect endangered species *in situ*. They must be managed," said Foose.

The workshop stressed the need to continue to protect the rhinos at Ujung Kulon and for a field programme to gather more information by tagging them with radio devices. There were also some more controversial suggestions. One was to set up at least two populations in captivity. A second was to move some of the animals from Ujung Kulon to other reserves in areas where the rhino used to live. When necessary, animals would be moved between the groups to ensure that genetic material mixed and that genetic diversity was preserved.

The idea is ambitious and will not be easy to follow through. In a zoo it is relatively simple to observe animals and even to take blood samples. For the programme to work, the same sort of information on the biology and pedigrees of the wild animals is needed. But these animals live in dense tropical forest and are difficult to find, let alone recognise as particular individuals.

Artificial insemination and embryo transfer are almost routine procedures in zoos today (see "Sperm you can count on", *New Scientist*, 10 June 1989). In the wild, these techniques could invigorate dwindling gene pools without the problems of moving animals. But they are practically impossible to carry out outside a zoo. As Bill Holt, of London Zoo, points out, the techniques rely on the female being in oestrus, and complicated hormone assays are needed to check that the animal is ready. These tests can be done only in a well-equipped laboratory—and once the results are known speed is of the essence. Simple logistics rule out any attempt at these procedures in the field.

Gilpin also points out that the techniques of zoo management are an expensive way to guarantee the survival of wild populations. But he admits that for very small populations it is not practical just to leave the wild animals to their own devices. Ideally, he would like to see some of the legwork—such as population viability analysis—done before a species becomes an emergency case. At that stage it should still be possible to protect the animals in other ways, by improving the habitat they live in and protecting them from disease.

Many animal rights groups and conservationists worry about the ethics of interfering with animals in the wild. The proposed management plan for the wild Javan rhinos has met opposition, both from conservationists involved in last year's workshop and others. The main concern was about the number of animals that could safely be taken from the wild.

In the US, the Fish and Wildlife Service has run into a similar problem in its efforts to manage the Florida panther. Plans for a captive breeding programme, devised at another IUCN workshop and based on population viability analysis, have been held up because of protests from pressure groups.

The workshop, held last November, included members of the captive breeding group, representatives from Florida zoos and other interested agencies under the umbrella of the Florida Panther Interagency Committee. They recommended an immediate programme of captive breeding and more management of the animals in the wild. They also suggested expanding the scheme to reintroduce the animal to the wild, while at the same time increasing efforts at conserving the panther's habitat. The captive breeding programme would

involve the Department of Fish and Wildlife, a private captive breeding facility and zoos.

The plan was to take four wild adults and six kittens in 1990, and then one pair of adults and six kittens a year for the next two years—but not a single panther has been taken from the wild so far. Trapping should have begun last spring in the Everglades National Park, but there was an outcry from the public.

Jasper Carlton, coordinator of the pressure group Earth First!, is not convinced that the Fish and Wildlife Service can successfully breed and release Florida panthers into the wild. Carlton's movement and others urged the Fish and Wildlife Service to change its programme, taking only kittens, and only on an experimental basis. They reason that every adult taken from the wild population reduces the species' chance of survival in its natural habitat. Kittens have a low chance of survival in the wild and stand a better chance in captivity. Carlton calls for a greater commitment to restore and enhance the panthers' habitat. Captive breeding programmes have an unhappy history in the US: Carlton points to the demise of the Californian condor and black-footed ferret, both of which were taken into captivity in a last-ditch attempt to save the species. "We doubt whether these species will ever successfully recover in the wild," says Carlton.

"If they do the same with the Florida panther there will be a fight on a national scale," says Carlton. He does not object to the principle of captive breeding programmes, but he is worried about them taking place in commercial zoos, as will be the case with the Florida panther. "The Fish and Wildlife Service have decided to put genetics ahead of habitat protection," he says.

Foose says that the zoos selected for the panther project are all involved in conservation, and that a good deal of effort is going into protecting and improving habitats suitable for both the black-footed ferret and the Californian condor, so that captive-bred animals will have somewhere to live when they are released into the wild.

Ulysses Seal, chairman of the captive breeding group says: "When a species is endangered there are always a lot of conservation groups involved. There are also a lot of suggestions based on science, without any science being done."

He supports the survival programme for the Florida panther and believes that population viability analyses will help in getting things done quickly. "What we want to do is prevent the extinction of any species through neglect," says Seal.

Both Foose and Seal believe that in the next 50 years at least 1500 species will need a species survival plan involving captive and wild populations. These range from the Bali starling to Sumatran tigers, Asian lions and the African elephant. Their vision is of a world where zoo populations and wild populations complement each other; where humans carry out migrations when no natural corridors connect the animals—a world where good management exists for all animals. Yet Seal stresses that close management will be necessary only until wild populations are able to sustain themselves and are secure."

The first steps have already been taken. Computer databases, analysis programs and techniques in genetics and reproductive biology have helped zoos to breed and reintroduce endangered species such as the golden lion tamarin and the Arabian oryx. Some of the techniques that have helped these animals are now becoming available to field workers. But the success of species survival plans depends on acceptance by other conservationists, many of whom have different views on the best way to stop extinction. □

Claire Neesham is a writer on science and technology.

WWF Indonesia Programme
PO Box 133, Bogor
Indonesia
6 March 1990

Dr Simon Stuart
Species Programme Officer
Species Survival Commission
IUCN Secretariat
CH-1196 Gland, Switzerland

Dear Simon,

I am sorry for the long delay in writing to you. This is simply due to the fact that I had been away in China and got back to Indonesia only three days ago. I was very happy to learn that you are the proud father of a baby daughter. Please convey my congratulations to Anne. Hope the mother and daughter are keeping fine.

I am in receipt of your letter of 1 Feb (unsigned) that you sent me in response to my fears on the pitfalls of the Javan rhino conservation. Perhaps I have not conveyed to you clearly what my objections were, in which case I am sorry. It is not that I am against the re-introduction programme. I do feel that it would be a good insurance policy if we could establish a second population of Javan rhino within its former range in Indonesia. I have no problems with this approch.

What I was and am concerned about is the capture of so many animals (18-26) from Ujung Kulon to be bred in captivity before the progeny could be re-introduced into the wild. Having seen the Sumatran rhino capture programme (a fiasco as far as conservation is concerned), I am sceptical if much good would come out if such a programme is adopted in the case of the Javan rhino as well.

What I feel is that we must do our best to protect the Javan rhino in its present habitat while there is still time in order to enhance its long term survival. But at the same time, it would make sense if a few founders (say 6 animals) were to be re-introduced into a suitable reserve within its former range in Indonesia and monitored carefully to see that these survive and reproduce in the wild.

I am not against re-introduction per se. I am only worried if the Zoos (very rich and powerful) were to concentrate on the capture of the Javan rhino for breeding in Zoos.

With all best wishes.

Yours sincerely,

Charles

Dr Charles Santiapillai

cc: K. MacKinnon, C. Hails, A. Fernhout, P. Moehrle, Chron File.
NB: Simon, you forgot tp enclose the copy of your letter to W. Thomas! Do let me have a copy. Thanks.

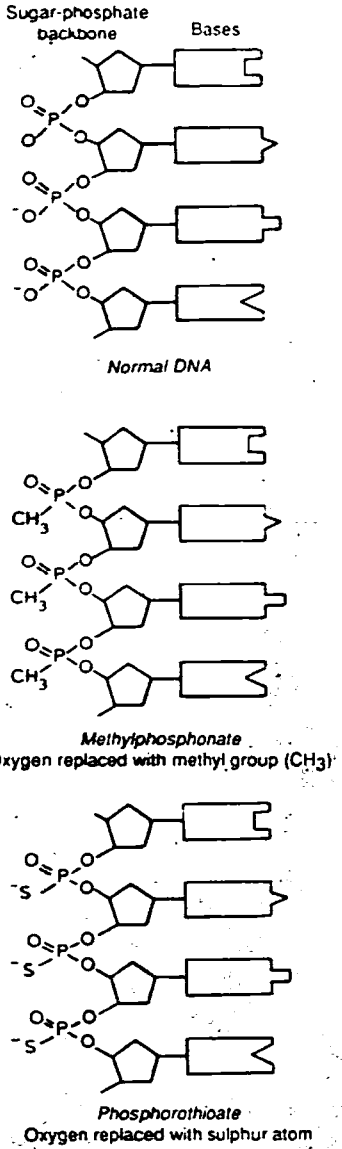
How to go wild

Zoos rightly gain kudos by providing animals for reintroduction to the wild. But setting captive-bred animals free involves far more than simply opening the cage door

Mark Stanley Price and Iain Gordon

THROUGHOUT the world, we are driving species towards extinction at an ever increasing rate. In the early 1960s, zoos began to emphasise their role as arks that might save such endangered species. By breeding animals in captivity and then releasing them in protected reserves, we might rescue some species. Yet well-meaning conservationists often give too little thought to how the animals will fare once they have gone "back to nature". Ecologists now realise, for instance, how much harder it is to survive as an orang-utan than an oryx. Reintroductions of some species, it seems, are fraught with difficulty and may even be doomed to failure.

In the past, many animals have been reintroduced to the wild in an unplanned and haphazard manner. In the 1970s, for example, conservationists returned the nene, the Hawaiian goose, to its native islands after it bred successfully at reserves run by the Wildfowl Trust in Britain. But the release of 1244 birds on Hawaii and 391 on Maui Island over 16 years has failed: the nene has not established a self-sustaining population anywhere in the Hawaiian archipelago. The reintroductions failed for several reasons. The nene spends much time on the ground, and the adults moult when leading their young, and so cannot fly, making both the adults and young



Chemical analogues that mimic antisense DNA may prolong its life in the cell. Researchers have synthesised these two variations by replacing oxygen atoms

inoculations by altering them so that they produce more antisense RNA (see "Brave new botany", *New Scientist*, 3 June 1989).

No one knows why the antisense RNA protects plants from the virus. Unlike most viruses, CMV uses RNA rather than DNA as its genetic material. The virus does not need to produce mRNA to make its coat protein because it can trick the ribosomes in the plant cells into using the RNA already carried by the virus. The antisense RNA engineered into the plants binds to the RNA that codes for the coat protein and so it might prevent ribosomes from using this RNA to synthesise proteins. But there is another possible explanation. The sequences that the virus needs to replicate its RNA are near the gene for the coat protein. The antisense RNA might also bind to these sequences and so perhaps it protects plants by preventing the virus from replicating rather than by reducing the supply of coat protein. Support for this idea comes from work by Keith O'Connell at Monsanto in St Louis, Missouri. Researchers have produced tobacco plants that make antisense RNA from the coat protein gene that does not bind to the nearby replication sequences. These plants are not protected from the virus.

Experiments to investigate the implications of antisense technology for medicine are still at an early stage. Both cancer and viral diseases might one day be treated by injecting short lengths of antisense DNA, synthesised artificially. This would remove any need to alter the cells of the patient by "gene therapy".

The obstacle to all cancer therapies is the need to kill or inhibit cancerous cells without harming healthy cells. The pairing of complementary sequences of bases in DNA or RNA is one of the most accurate systems of recognition found in nature; harnessing it with antisense DNA may be the key to the treatment of some cancers.

Several cancers are known to be associated with mutations in a particular gene. For example, 40 per cent of cancers of the colon are associated with mutations in a small section of the gene known as c-Ki-*ras*. David Tidd from the University of Liverpool is exploring the feasibility of using antisense DNA in the treatment of these cancers. He predicts that antisense DNA may be able to distinguish between normal and mutated genes. This would mean that it could be used as the basis of a therapy that inhibited only the cancer cells bearing the mutated genes, perhaps even converting them back into normal cells.

This idea might also work in the treatment of viral diseases. So far research has concentrated on inhibiting HIV, the virus that causes AIDS, which, like CMV, uses RNA as its genetic material. John Goodchild from the Worcester Foundation for Experimental Biology in Shrewsbury, Massachusetts, has attempted to use short sequences of antisense DNA to stop HIV from replicating in cultured cells. He tested 20 different antisense DNA sequences, all of which were complementary to regions of the viral RNA. They all inhibited the virus to some extent, and the best of them compared favourably with drugs now in use. Although antisense DNA can inhibit the virus in tissue culture, it will be a long time before researchers can do clinical trials because there are many problems in administering it safely.

Mimicking DNA makes sense

One of the problems of using antisense DNA is that it is rapidly broken down by enzymes inside cells. So researchers must dose cells with too much antisense DNA so that enough survives to bind to mRNA. For this approach to be successful, we must find a way to protect antisense DNA from these enzymes. In view of this, many researchers are looking at the effects of using chemical analogues that mimic antisense DNA.

Chemists can make such analogues by replacing one of the oxygen atoms in the phosphate groups of the sugar-phosphate backbone of DNA with either a methyl group (CH_3) or a sulphur atom (see Figure). These DNA analogues are not recognised by the enzymes that would otherwise destroy them. Unfortunately, however, the analogues do not seem to be much better than normal DNA at blocking genes. This is because the effectiveness of antisense DNA partly relies on enzymes that destroy the mRNA strand when it is bound to a strand of DNA. If the enzymes do not destroy this bound mRNA, it is eventually freed from the DNA and so able to direct the synthesis of proteins. The difficulty with the analogues is that the enzymes are less able to destroy mRNA bound to them. So although the analogues survive for longer than normal DNA, in the end they lead to the destruction of a similar amount of mRNA.

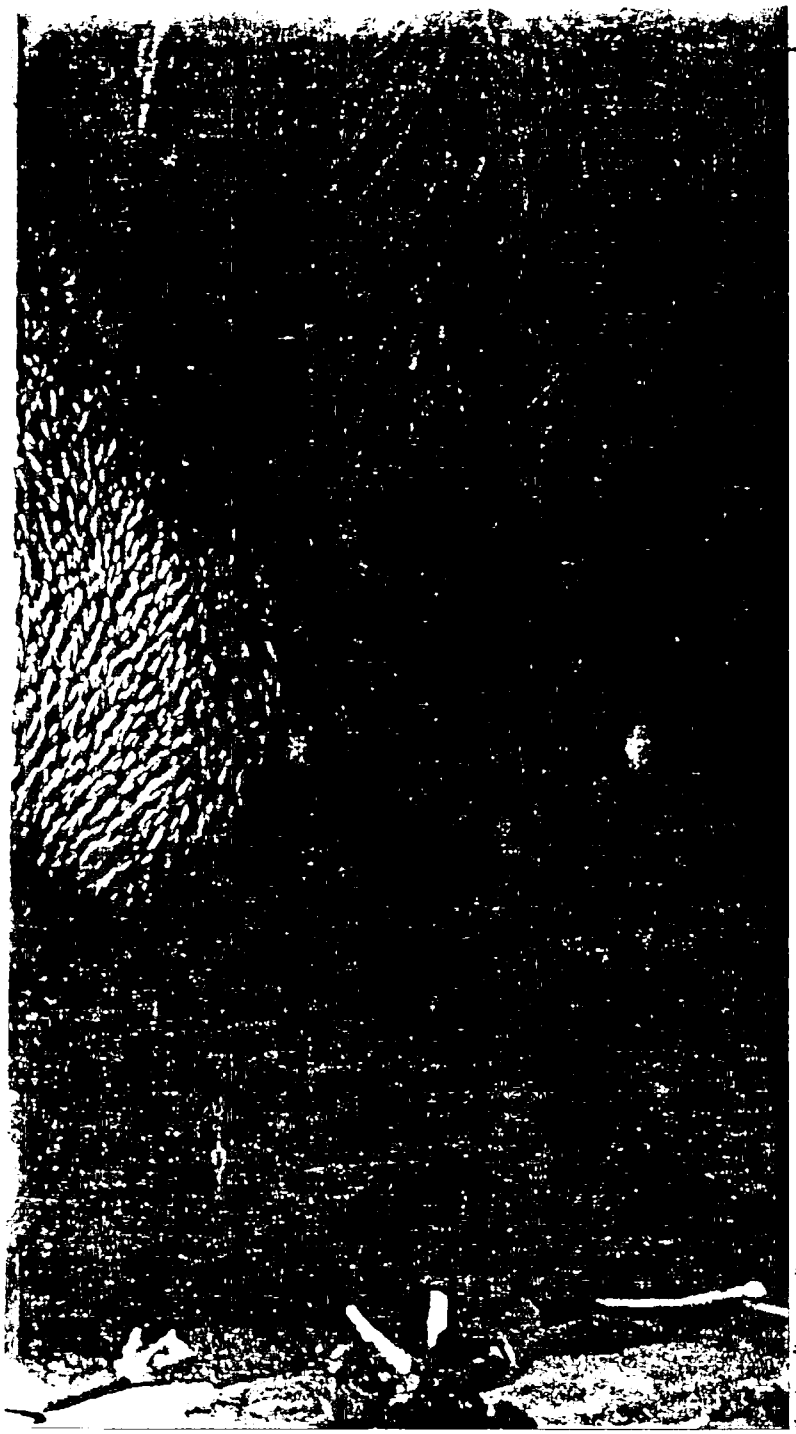
Tidd created DNA analogues in which he replaced the oxygen in the bases at the ends of the strands with a methyl group. These analogues appear to be promising because mRNA attached to them was destroyed while the analogues were still protected from the enzymes that destroy normal single strands of DNA.

Another way of improving the effectiveness of antisense DNA is to bind chemicals to the DNA strand that help to stabilise the hybrid double helix made of strands of mRNA and DNA. The idea is to prevent the mRNA from escaping before it is destroyed by enzymes. Claude Helene from INSERM in Paris has pursued this approach with encouraging results.

Charles Jennings and his colleagues at Harvard University are working to combine antisense technology with the recently discovered ribozymes. Ribozymes are enzymes made from RNA that are able to cut through other RNA strands. By attaching antisense RNA to ribozymes, they have been able to make them bind to and cut specific mRNAs found in eggs of the frog *Xenopus laevis*. So far they have achieved this only in the test tube, but they hope to be able to extend the technique to cells in living organisms. If they succeed, antisense RNA-ribozymes hybrids might make antisense technology even better at switching off genes.

Even if these improvements fail, antisense technology is already established as a powerful technique in both pure and applied research. Once a gene has been isolated, introducing an antisense version can switch it off in almost any organism. By switching off selected genes, scientists will be able to analyse how genes control complex biological processes such as growth and development—the knowledge we need for further advances in biotechnology and medicine. □

Stephen Day is a biologist and freelance writer based in Cambridge.



vulnerable to hunters, and to predators that people have introduced. Another factor which may have reduced their breeding success was that biologists released most of the geese in the mountains, which the birds originally used for only a short period each year.

Conservationists now realise the importance of a scientific approach to managing reintroduction. The Oman project to reintroduce the Arabian oryx is a shining example of this new attitude. Hunters exterminated the last wild herds of the Arabian oryx in Oman in 1972. Biologists in the US began to try to establish a captive herd of this antelope in 1963, and by the late 1970s the American herd was thriving. Between January 1982 and 1984, a team headed by Mark Stanley-Price released a total of 21 oryx as two herds into the Jiddat-al-Harasis, a stony desert plateau in central Oman. Seventeen of the founder animals came from the American herd, two from the Gladys Porter Zoo in Brownesville, Texas, and the remainder from the San Diego Zoological Society. One male oryx originated from the Jordanian national herd in 1984. Several calves were born in a large enclosure erected in an area of natural vegetation.

The first step towards any successful reintroduction is a feasibility study. We must know why the species became extinct in the wild, whether these conditions persist and whether suitable habitat remains to support a population. One such study, to examine the possibility of reinforcing the last remnants of a unique population of skinks, a type of lizard, living on Round Island, off Mauritius, concluded that reintroduction was likely to fail. The researchers found that the island was still ridden with introduced rats which had caused the original population to decline.

In the case of the Arabian oryx, little was known about the original populations, and so conservationists working to reintroduce this species relied on information about a close relative, the fringe-eared oryx in Kenya. Studies showed that oryx live in herds made up of males and females in roughly equal numbers. Bachelor herds do not occur, and single territorial males are rare. Herds establish a straightforward hierarchy that involves all females and males above the age of about seven months. In Oman the project workers tried to establish a herd of not less than 10 animals, with a roughly equal number of males and females and a range of years. The animals lived together in the enclosure long enough to develop a stable social group. When the oryx first arrived in Oman, Price and his colleagues kept them in groups in small pens for a few days before releasing them into the enclosure. Covering an area of 100 hectares, the enclosure was large enough for the animals to graze as a unit, and contained a variety of natural types of vegetation. As there was no artificial shade or shelter provided, the animals had to learn to exploit their environment in the full face of the desert climate.

Ready for freedom

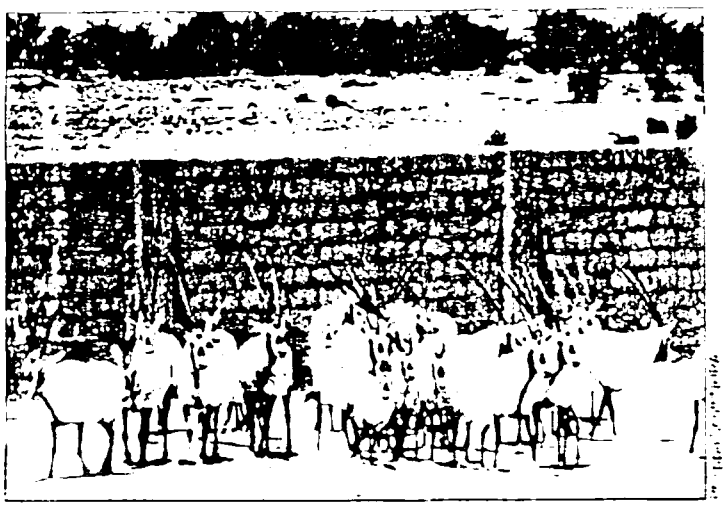
The herd had to meet two main criteria before we released it. First, the oryx had to have developed a stable and unambiguous hierarchy, with male A, say, always dominating male B in social encounters. Secondly, they had to exhibit the full range of social and sexual behaviours that are normal in a wild herd. For instance, dominant male oryx defecate in conspicuous places in a squatting position. In the first herd assembled in Oman, a male in the enclosure assumed dominance at the age of 24 months. But it was another 18 months, following the release of two older males into adjacent pens, before he started to squat-defecate in the enclosure. This indicated his social maturity and increased the likelihood that he would keep his herd together in the desert.

Monitoring the animals after release is also crucial. In the short term, the way released animals disperse is one measure of their response to the new environment. Knowing why any of the animals die also enables us to improve methods of managing them immediately, or at least before any more are released. In the reintroduction of another oryx species, the scimitar-horned oryx, to the Bou-Hedma National Park in Tunisia, the dominant male killed a young oryx calf, and several members of a herd of a related species of addax antelopes reintroduced to the same area. The project workers removed this aggressive animal from the main herd and kept a close watch on the interactions of the oryx and addax herds.

This emphasises the importance of being able to manipulate and manage the released animals in their native environment. The monitoring phase is often neglected once the released animals appear to be surviving. Because no one monitored the fate of the Hawaiian geese after their release, we still do not really know why only four of the 1600 released over 16 years managed to survive.

Not all species are equally amenable to reintroduction. We can draw up general rules to determine whether a species might be successfully re-established. Two contrasting reintroductions, the Arabian oryx and the orang-utans, illustrate the importance of trying to do this.

Many people have tried to reintroduce orang-utans to their native habitat. But it is not easy for many reasons. These



Captive-bred oryx adapt well to the wild, if the social relations within a herd are well established before the animals are released

animals need to learn much about their exceptionally complex environment and how to relate socially to other orang-utans. Conservationists soon found that reintroduced orangs were more likely than native animals to be killed by predators, probably because many of the newcomers often move about on the forest floor whereas the wild animals spend all their time in the trees.

Social skills are also very important, and depend in part on each animal's previous history: for example, animals that have spent a period in the wild in early life find it much easier to lead an independent life when reintroduced. Orang-utans also fare better if they have spent time with wild or more experienced individuals before their release.

In the wild, however, adult male orangs and adolescents live mostly alone, associating with females only to mate. Females live with dependent offspring. So orang-utans rarely interact with complete strangers, making the reception of the reintroduced orangs that much more fraught. Reintroduced animals generally move only about half a kilometre from where they are released because of the aggressive behaviour of wild orangs. This reluctance to move greatly reduces their chances of self-sufficiency because wild orangs need to move over wide areas of forest, following the fruiting pattern of the trees.

By contrast, Arabian oryx have a single social unit, the mixed male-female herd with long-term bonds between individuals that can be cemented before release. The herd then moves freely as a self-contained unit: the first herd of Arabian oryx established a home range of 1700 square kilometres two years after its release.

The desert environment also made life easier for the reintroduced oryx. This habitat lacks diversity: the Oman desert has only three species of low trees and between 30 and 40 common grasses, herbaceous plants and shrubs. Once released, the oryx ate almost every species available, and both after rains and in the dry season they ate staple grasses supplemented by a few ephemeral plants. In contrast, the rainforest that the orang-utans inhabit is a complex, mixed forest made up of a small-scale mosaic of habitats, with some trees as tall as 60 metres. Each orang-utan in the Sumatran forest may have to range over 2 to 3 square kilometres to find enough food, and individuals of the species live far apart. Unlike the oryx the orang-utans have a diverse diet. They eat fruits, leaves, bark, shoots and sometimes fungi and birds' eggs. These foods are highly dispersed: of the 28 chief species of fruit they eat in Borneo, 18 had densities of less than two trees per hectare. Each species of fruit is also available for only a very short period of time. So a rehabilitated orang-utan has to develop a varied diet through experience in a forest with complex and irregular fruiting patterns.

The reproductive biology of the orang-utans also makes it more difficult for them to establish a self-sustaining population. Despite the similar weights of Arabian oryx (55 to 75 kilograms) and orangs (30 to 80 kilograms) and gestation periods of 266 and 245 days, oryx become sexually mature much earlier and reproduce thereafter much more frequently than orang-utans. A wild female oryx has her first calf before she is three years old and can then calve every 9 to 12 months. In Oman the number of animals in the herds increased by 22 per cent each year. By comparison, wild orangs conceive for the first time when they are between 13 and 15 years old and produce offspring only once every six to seven years thereafter. So their low rate of increase hinders the establishment of a viable population unless vast numbers are released.

The reintroduction of Arabian oryx into Oman also showed that success partially depends upon the ability to monitor the population's performance. Monitoring in the desert and in the orang-utan's forest requires very different techniques. Visibility in the oryx's desert environment is good and the terrain is easy for a vehicle to move through. Because oryx live in herds and remain in a relatively circumscribed area for weeks or months, they are easy to track down daily. The forest is the opposite in every respect: visibility is low, and locating the orang-utans on consecutive days is almost impossible because the dispersed nature of their food supply requires them to be constantly on the move. All of this makes the reintroduction of orang-utans labour-intensive and costly compared to oryx, particularly as each orang-utan needs intensive rehabilitation before it is released.

All these factors permit the orang to be firmly placed into a class of animals whose biology and ecology makes them difficult and expensive to reintroduce. It is a highly specialised species, with a low reproductive rate, living in a hazardous and competitive environment, which allows researchers to observe released animals only sporadically. But the Arabian oryx project in Oman shows how successful reintroductions can be. Large ungulates, hoofed mammals, appear to be good candidates for reintroduction. Most successful efforts show how important it is not merely to have good scientific data on the species, but also a deeper understanding of how native animals bred in captivity will perceive and respond to their native, but novel, habitat. Our success at reintroducing wild ungulate species may be helped by our long history of managing and domesticating their relatives, cattle, sheep and goats. But we are a long way from being able to "save" any given species by reintroducing zoo-bred animals. □

Mark Stanley Price is director of the African Wildlife Foundation in Nairobi and was field manager of the project to reintroduce the Arabian oryx to Oman. He is the author of *Animal Re-introductions: the Arabian Oryx in Oman*, Cambridge University Press 1989. Iain Gordon works at the Macaulay Land Use Research Institute in Edinburgh. He is also a consultant biologist for the Zoological Society of London's project to reintroduce scimitar horned oryx to Tunisia. Both authors will speak at a symposium at the Zoological Society of London on 24-25 November, entitled *Beyond Captive Breeding: Reintroducing Endangered Mammals to the Wild*

RHINOS:

Biggest threat is poaching (80-90% mortality).
at this rate, Sumatran rhino could be extinct on 96% of its locality by the year 2010.

Captive Breeding:
Theoretical judgements for CB are highly subjective & prominently prejudiced against certain aspects of in situ management options.

Since 1984, a total of 27 Sumatran rhinos were caught and 19 are kept in 8 captive facilities in Indonesia, Malaysia, USA and UK.

Over a six year period, 29.6% of the Sumatran rhinos died without contributing any genetic material towards species conservation.

As with the Black rhino in Africa and the Indian rhino in other modern and sophisticated zoos, Sumatran rhino CB programmes are facing similar difficulties of high captive mortality and clinical management problems.

Diseases accounted for 50% of mortality, with 37.5% from post-capture problems and 12.5% due to accidents.

Stillborn calves accounted for 13.8% of the 36 Indian rhino calves born during 1956-1975.

Present CB programme for Sumatran rhino suffers from a skewed sex ratio in favour of the females which account for 74% of the animals captured. (In Malaysia, 80% of the captured animals are females).

Although there are sufficient numbers of breeding males and females (S. rhino) in captivity, sectarian sentiments prevent them being optimally used in a large breeding programme.

Progeny born and bred in temperate Zoos might not be suitable for reintroduction into the dense and humid TRF.

British and America Zoos have would like to have a conservation angle to their CB programme as far as the Sumatran rhino is concerned, but in practical terms, they are in fact treating the CB project as an animal acquiring project.

Much more could be done to in situ conservation if there is a will. CB programmes have diverted large sums of money that otherwise could have used to protect rhino habitats.

In Malaysia a trapping programme costs about US$ 2,500/rhino, while in Indonesia, it ranges from US$ 150,000 to 200,000 per animal exported to the Zoos.

CB is more risky: mortality due to diseases can be as high as 50% and trapping fatalities about 11.1%.

Intensive management of rhinos requires large areas with adequate facilities. In Many Zoos, space is a limiting factor.
Many Zoos will therefore cannot accommodate the founder population of 20 animals.

In-situ successes:

1. In Kaziranga NP in Assam, India: Number of Indian rhino (closely related to Javan rhino) increased its number from a dozen or so in 1908 to about 400 in 1940. Today, there are over 1000 animals.

2. In Chitwan NP, in Nepal, the Indian rhino increased its number from 160 in 1966 to 375 in 1984.

3. In Garamba NP in the Congo, the number of rhinos increased from 100 in 1939 to more than 1000 in 1963.

4. In Umfolozi NP in S.Africa, the number of white rhino increased from 20 to over 600 within 50 years in an area comparable in size to that of Ujung Kulon NP.

Recommendations:

1. Improve the protection of all the rhino reserves.

2. Capture the so called doomed rhinos and relocate them into protected areas that are secure. (as in India where 9 Indian rhinos were translocated from Assam and Chitwan to Dudhwa NP. 77.7% of the translocated animals survived. In S. Africa, excess white rhinos were translocated and several populations have been established in their former ranges.)

3. We should seek funds for rhino conservation from local and other International Organizations which have no vested interest in the species other than a desire for its long term in-situ survival.

4. PVA is often based on inadequate data and thehrefore is unreliable. As far as the Sumatran and Javan rhinos are concerned, Protection is easier, cheaper and more likely to be successful than captive breeding as recommended by PVA which is difficult, expensive and likely to fail.